SYNOPSIS OF RESEARCH PROJECT

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8. Title of Research Project **: COMPARATIVE PERFORMANCE OF GROUNDNUT AND SESASAME INTERCROPPING UNDER DIFFERENT PRODUCTION SYSTEM**

9. Introduction

Groundnut (*Arachis hypogaea* L.) is self-pollinated, annual herbaceous, autotetraploid legume with 2n=40 chromosomes belonging to the family Fabaceae. Groundnut is also known as the "Wondernut" or "Poor man's Cashewnut". The crop has its own importance due to high edible oil content and nutritional value of kernel as human food and haulm as rich feed for animals. The groundnut kernel contains 48-50% edible oil. The oil is generally used in the preparation of vanaspati ghee, soaps, cosmetics and cold creams besides as cooking medium. It is light yellow in colour and sweet in taste and flavour. It is good from both nutritive and culinary point of view as it contains good quantities of MUFA (mono unsaturated fatty acid) (oleic acid, 40-50%) and PUFA (poly unsaturated fatty acid) (linoleic acid, 25-35%). With its high oleic/linoleic ratio, groundnut oil has a relatively longer shelf life. The tocopherol (approximately 0.9 mg/g oil), an antioxidant present in groundnut oil

prevents development of rancidity. Oil is a rich source of vitamin A, B and E. The remaining 50% of the kernel has high quality protein, on an average 25.3% which is about 1.3 times higher than meat and 2.5 times higher than eggs, carbohydrates (6.0 to 24.9%) and minerals and vitamins (Das,1997).

Kernels are also being used as processed foods like sweets and dry powder. Groundnut haulm and oil cake are used either as cattle feed or organic manure. The shells of groundnut are also utilized as fuel in boilers and as filler material in many organic and biological products like activated charcoal, cork substitutes and hard boards. Its inclusion in crop rotation builds up soil fertility by fixing atmospheric nitrogen through root nodules and serves as an efficient cover crop for reducing soil erosion and helps in water conservation.

Globally, groundnut is cultivated on an area of 29.81 m ha with a production of 49.45 million tonnes with an average productivity of 16.59 q/ha. Among different countries, India, China, Nigeria and Sudan have the highest area under groundnut cultivation in the descending order. India contributed 19% to the total groundnut production of the world in 2021. India ranks first in area and second in production after China. In India, groundnut is cultivated in 6.09 m ha area with a production of 10.21 million tonne and productivity of 16.76 q/ha (Anonymous, 2022).

In India, 80 per cent of groundnut area and 84 per cent of the production is confined to the states of Gujarat, Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and Maharashtra. In India, Gujarat holds first position in groundnut production (4.13 million tonne) and contributes 35.50% to the area (2.16 m ha) having share of 40.42% with an average productivity of 19.08 q/ha (Anonymous, 2022). In Gujarat, groundnut is cultivated during *kharif* as well as summer seasons. The groundnut cultivation in Gujarat is largely confined to Rajkot, Morbi, Junagadh, Jamnagar, Amreli, Bhavnagar, Porbandar, Devbhumi Dwarka, Kutch and Banskantha districts. The Saurashtra region of Gujarat considered as 'Bowl of groundnut'. However, recently it has also been noticed that the area under groundnut cultivation is increasing in potato growing belt of North Gujarat because of suitable agro-climatic conditions and coarse texture of soil.

Sesame (*Sesamum indicum* L.) is the oldest spice in the world and an ancient oilseed crop that was first farmed about 3000 years ago. It is primarily valued for its oil content (48–55%) and protein content (25%). Of the several species in the genus, the majority of wild species were indigenous to Sub-Saharan Africa, whereas *S. indicum*,

the cultivated species, originated in India. It goes by the name "Queen of oilseeds" as well. Pedaliaceae is an annual herbaceous plant that includes sesame (*Sesamum indicum* L.). It is grown for its edible oil, which is high in unsaturated fatty acids, and its seed, which is high in protein. The world uses a significant portion of its sesame crop for oil.

Many types of soil have been adapted to by sesame cultivars. The finest soils for high- yielding crops are medium-textured, neutral-pH, well-drained, and fertile. These, however, do not do well in highly salted or wet soil environments. Sesame crops grown for commercial purposes need 90–120 frost-free days. Warm temperatures above 23 °C (73 °F) promote yields and growth also in quality in some extent. Although sesame crops can be grown in unfavorable soils, farms with enough fertilizer provide the highest yields. Photoperiod and sesame variety affect blooming initiation. Sesame seed oil content is also influenced by photoperiod; a longer photoperiod results in a higher oil content. There is inverse relationship between the seed's oil content and protein content. Sesame is drought-tolerant, in part due to its extensive root system. However, it needs enough moisture to germinate and begin growing. The crop can withstand both drought and an abundance of water, although its yields are much reduced in both situations. Yield is mostly influenced by the moisture content prior to planting and flowering.

Gujarat is one of the top states in India. According to the Directorate of Agriculture's third advance estimate, the state's cultivated area for sesame reported about 1.508 lakh hectares, production estimates of sesame are 125.38 thousand tonnes (Anonymous, 2022).

Intercropping is the practice of growing two or more crops simultaneously on the same field. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop. Intercropping is a common practice followed by farmers of semiarid and arid tropics. A significant feature of intercropping is that, it is biologically more dynamic than a sole crop and is therefore, less likely to succumb to vagaries of weather Therefore, intercropping is intrinsically more secure and dependable in providing some returns than sole cropping. Intercropping also reduces the damage caused by weeds due to smothering effect and disburses substantial benefits from medium to high levels of technology, comprising, fertilizer use, pesticide use and high yielding varieties adaptation. Through proper selection of

crops, inter-cropping may also provide balanced diet to the farmers, i.e. carbohydrate through cereals, protein through legumes and fat through oil seed crops. When legumes are grown in association with non-legumes, there is often advantage to the non-legumes from nitrogen fixed by the legumes. Intercropping is an efficient strategy that can be followed with desirable outcome in the changing climatic scenario.

Intercropping is additionally a component of intensive cropping, which is geared toward crop intensification. The good thing about this technique is geared toward maximum utilization of natural resources like rainfall, radiation, irrigation, and soil for higher crop production. The intercropping system provides insurance against failure moreover as stability in yield in aberrant weather. The cereal + legume intercropping is that the most ordinarily practiced system of intercropping having crops complementary effects instead of competitive effects. In intercropping, the row arrangement of crops is a crucial aspect to be considered. The correct spacing, of the component crops, is subjected to least by adjusting the rows for most of the crops with the accommodation of intercrop. It ensures penetration of an affordable amount of radiation for the dwarf component of system without much competition for space and nutrients.

The excessive and imbalanced use of inorganic fertilizers has led to poor soil health, reduced crop productivity and reduced profitability due to increased cost of cultivation. Natural/organic sources are a cost effective and eco-friendly alternative to inorganic ones. These sources enhance soil health, biodiversity and soil quality by eliminating pesticides and utilizing a diverse range of plants.

Application of natural/organic inputs maintain and improve soil physical, chemical and biological properties which in turn are reflected in the crop yield and sustainability. Natural or Organic farming utilizing nutrient sources like farm yard manure, Jeevamrit, Ghanjeevamrit, Beejamrit etc. are known to increase crop yield and promote sustainable agriculture development.

Beejamrit is prepared from dung and urine of desi cow and burnt lime. It is used for the treatment of seeds, seedlings and other planting material. It protects the crop from harmful soil borne and seed borne pathogens during the initial stages of germination and establishment. The treated seeds germinate faster and have higher germination capacity. The plants have more tolerance to adverse climatic conditions, insect pests and disease.

Jeevamrit is a fermented microbial culture prepared from mixture of dung and

urine of indigenous (desi) cow, pulse flour and undisturbed or barren soil which acts as inoculate of native species of microbes and organisms. It is a plant growth promoting substance containing beneficial microorganisms which promotes growth and yield of crop. Microorganisms are well activated in the soil by the addition of Jivamrut. The microorganisms such as nitrogen fixer- Azotobacter, Azospirillum and phosphorus solubilizing bacteria Pseudomonas fluorescence and potash solubilizing bacteria like Bacillus silicus are present in the cow dung that is used to prepare jivamrut (Ramprasad *et al*., 2009).

Ghanjeevamrit enhance the microorganism population in the soil, including bacteria, fungi and actinomycetes, helps in converting the organic matter into readily available plant nutrients, thereby improving soil chemical and physical conditions. It can be used in rainfed areas for better crop growth.

Organic manures are playing important role in crop production. It acts on the soil physical properties, organic matter promotes formation of soil crumb, thus makes the soil friable and thereby, facilitates the proper movement of air and water as well as absorption of rain water. It also adds plant nutrients to the soil and organic acid during dry matter decomposition which act on the insoluble nutrients reserve in the soil and make them available.

Farm yard manure (FYM) is the principal source of organic matter in our country which has being used since antiquity of man. It contains 0.5 % N, 0.2 % P_2O_5, and 0.5 % K_2O. Organic carbon in the organic matter act as a source of energy for soil microorganisms and upon mineralization release essential elements during crop growth. In addition to supply of available plant nutrients directly (Cooke, 1967), the use of FYM also mobilizes the unavailable nutrients present in the soil system.

The NPK consortium is a liquid biofertilizer. It contains *Azotobacter* (N), Phosphate Solubilizing Bacteria (P) and *Frateuria aurantia* (K) in equal proportions. It is highly effective in results and prove highly favorable for plant growth. It fixed atmospheric nitrogen, solubilize existing soil phosphates and mobilize soil potash. It converts non available forms of micro nutrients into available form.

10. Practical Utility of the Research Project

The research on the comparative performance of groundnut and sesame intercropping under different production systems provides practical insights for improving productivity, profitability, and sustainability of oilseed-based cropping systems, particularly under rainfed and semi-arid conditions. The study helps identify

efficient intercropping combinations and suitable production systems that optimize land use efficiency, resource utilization, and system yield. Groundnut–sesame intercropping promotes better utilization of soil moisture, nutrients, and solar radiation, while groundnut, being a legume, contributes to biological nitrogen fixation, thereby enhancing soil fertility and reducing fertilizer dependency. The results assist farmers in selecting appropriate production systems (conventional, organic, or low-input) based on their resource availability and management capacity. Economically, the findings demonstrate the potential of intercropping to increase net returns, improve benefit–cost ratio, and stabilize farm income by reducing the risk associated with sole cropping. The diversified system also enhances cropping intensity and employment opportunities.

Too far, very little systemic study has been conducted to assess the comparative performance of groundnut and sesame intercropping under different production systems. In light of previously mentioned facts, a field experiment will be carried out at the instructional farm Department of Agronomy college of agriculture JAU, Junagadh- 362001, during summer season of 2026.

11. Objectives

1. To study the performance of groundnut and sesame as a sole crop under different production system
2. To study the performance of groundnut and sesame as a intercropping under different production system
3. To study the effect of different production system on soil status and nutrient content and uptake
4. Economics evaluation of different treatments

12. Review of Literature

12.1 Effect of intercropping

12.1.1 Effect on growth, yield attributes and yield

Sarkar *et al.* (2003) conducted a field experiment to evaluate the productivity and economic viability of sesame based intercropping systems under rainfed upland conditions of the Gangetic alluvial zone of Kolkata, West Bengal. The study was carried out during the *kharif* seasons of 2000 and 2001. The results revealed that sesame grown as a sole crop in paired row spacing (30/60 cm) attained significantly greater plant height compared to sesame planted in uniform row spacing (45cm) as well as sesame grown under various intercropping combinations.

Chand *et al.* (2004) observed that intercropping chickpea with mustard at row ratios of 6:2 and 8:2 resulted in a reduction in the average seed yield of chickpea by 35.9 and 28.3 percent, respectively, compared to sole cropping of chickpea. However, among the different intercropping arrangements, the chickpea–mustard system with an 8:2 row ratio produced a relatively higher chickpea yield than the 6:2 row ratio.

Krishna *et al.* (2004) carried out a field experiment during the summer season of 1998 at Tirupati, Andhra Pradesh, to compare the effectiveness of skip-row planting of sesame with uniform row spacing while maintaining the same plant population, and to examine the suitability of green gram as an intercrop under irrigated conditions. The study revealed that sole sesame grown under the double-row single-skip planting pattern produced significantly higher seed yield. In addition, green gram maintained at 100 per cent population exhibited superior yield attributes, including a greater number of branches per plant, pods per plant, seeds per pod and higher test weight, compared to green gram grown at 50 per cent population.

Krishna and Reddy (2005) reported that intercropping greengram with summer sesame under irrigated conditions increased sesame plant height compared to sole cropping. The tallest sesame plants were observed when green gram was grown at 100 percent population in a single-row, single-skip planting geometry.

Mahale *et al.* (2008) reported that a field experiment conducted during 2005–06 at Dapoli, Maharashtra, showed significantly higher seed yield of sesame under the sesame + groundnut intercropping system with a 3:1 row ratio. In contrast, sesame grown as a sole crop produced a significantly greater stalk yield, which was reduced under all intercropping treatments.

Dhimmar and Raj (2009) carried out a field experiment at the Integrated Oilseed Research Farm, Navsari Agricultural University, Gujarat, during two consecutive *rabi* seasons from 2004 to 2006 to assess the productivity potential of castor-based intercropping systems with different pulse crops and planting patterns. The study revealed that intercropping significantly decreased castor plant height, while the tallest plants were recorded under sole cropping of castor.

Abraham *et al.* (2010) carried out a field experiment during the *rabi* seasons of 2005–06 and 2006–07 at the Agronomy Research Farm of Amar Singh (P.G.) College, Lakhaoti, Uttar Pradesh, to evaluate the effects of irrigation levels and fertility gradients on dry matter accumulation, nutrient uptake and yield in a chickpea-based intercropping system. The results indicated that chickpea intercropped with

mustard in a 4:1 row ratio outperformed the sole cropping of either chickpea or mustard with respect to yield and harvest index.

Pouramir *et al.* (2010) conducted a field study during 2007 at Ferdowsi University of Mashhad, Iran, to assess the influence of different row proportions in a sesame + chickpea intercropping system on crop yield. The findings indicated that the maximum sesame seed yield was recorded when sesame was intercropped with 20 % chickpea + 100 % sesame, whereas the lowest yield occurred under mixed planting with 10 % chickpea and full sesame population. Similarly, Yadav *et al.* (2013), based on experiments conducted during the *kharif* seasons of 2009 and 2010 at Kanpur, Uttar Pradesh, reported that sesame grown under intercropping systems exhibited reduced canopy development compared to sole sesame cropping.

Yadav *et al.* (2015) carried out a field experiment during the summer season of 2010 at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Gujarat, to evaluate intercropping systems in summer pearl millet. The results revealed that sole pearl millet recorded the maximum plant height and produced the highest grain yield compared to intercropped treatments. However, among the intercropping systems, the pearl millet + sesame combination in a 1:2 row ratio achieved the highest harvest index.

Sarma *et al.* (2016) carried out a field study during the *kharif* seasons of 2010–11 and 2012 at the research farm of the All India Coordinated Research Project for Dryland Agriculture, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, to evaluate the feasibility of intercropping green gram and blackgram with sesame. The results indicated that both sesamum and the intercrops attained maximum plant height when grown as sole crops compared to intercropping systems.

Das *et al.* (2017) carried out a field experiment during the winter seasons of 2013–14 and 2014–15 at the Research Farm of the College of Agriculture, Central Agricultural University, Imphal, on well-drained clay loam soil to assess the productivity, biological suitability and economic feasibility of chickpea–rapeseed intercropping across various row ratios. The study showed that sole cropping of both chick pea and rapeseed produced significantly higher grain and straw yields compared to all intercropping treatments.

Kumar *et al.* (2017) evaluated the productivity and economic performance of different sesame based intercropping systems through a field experiment conducted during the summer season of 2016 at the College Farm, Navsari Agricultural University, Navsari, Gujarat. The results indicated that sole cropping of sesame produced significantly higher seed and stalk yields compared to the intercropping treatments.

Moinuddin (2017) carried out a field experiment during the pre-*kharif* season of 2015 at the Regional Research Station, Jhargram, Bidhan Chandra Krishi Viswavidyalaya (BCKV), West Bengal, on red and lateritic soils to assess the feasibility of green gram–sesame intercropping under different planting ratios. The study revealed that yield attributes such as number of branches, pods per plant and pod length in green gram, as well as number of seeds per capsule in sesame, were superior under the 2:2 row ratio compared to the 1:1 and 1:4 planting patterns.

Ramarao *et al.* (2020) conducted a field experiment during the *rabi* season of 2017 at the Main Research Station, University of Agricultural Sciences, Dharwad, to evaluate the effect of different chickpea–mustard row ratios on the growth, yield and quality of mustard. The results showed that sole cropping of mustard produced significantly higher seed yield, straw yield and harvest index compared to intercropping treatments.

Panda *et al.* (2022) conducted a field experiment during the summer season of 2020–21 at the Experimental Farm of Centurion University of Technology and Management, Paralakhemundi, Odisha, located in a tropical region. The findings revealed that sole cropping of sesame resulted in significantly higher yield compared to other treatments.

Yadav *et al.* (2023) carried out a field experiment at MJRPU, Jaipur, during the summer seasons of 2021 and 2022 on sandy loam soils to evaluate the response of pearl millet [*Pennisetum glaucum* (L.)] intercropped with green gram [*Vigna radiata* (L.)] in terms of yield and economics. The results indicated that sole transplanted pearl millet at 45 cm spacing recorded the highest straw yield (7986 kg/ha), followed by transplanted pearl millet + green gram in a 2:1 row ratio at 45 cm spacing (7778 kg/ha) and sole drilled pearl millet at 45 cm spacing (7361 kg/ha).

Kumar *et al.* (2024) conducted a field experiment during the *kharif* season of 2020 in Haryana under dryland conditions to evaluate the performance of pearl millet–legume intercropping systems. The study revealed that pearl millet grown as a sole

crop at 45 cm spacing recorded the highest yield attributes, which were closely followed by the pearl millet + green gram intercropping system in an 8:4 row ratio at 30 cm spacing.

Shiyal *et al.* (2024) conducted a field experiment at the College Farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, during the summer seasons of 2021 and 2022 to evaluate the influence of pearl millet + pulse intercropping systems and nutrient management on the growth and yield of pearl millet (*Pennisetum glaucum* L.). The results indicated that sole pearl millet recorded the highest grain (2562 kg/ha) and straw yields (5551 kg/ha), which were statistically comparable to the pearl millet + green gram intercropping system in a 2:1 row ratio, yielding 2502 kg/ha grain and 5485 kg/ha straw.

Sowmiya *et al.* (2024) conducted a field experiment during the *rabi* season of 2023–24 at Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, to evaluate pearl millet based intercropping systems under rainfed conditions. The study showed that pearl millet intercropped with green gram in a 4:1 row ratio recorded the maximum plant height (185.18 cm), followed by the 6:1 ratio. However, sole pearl millet produced the highest grain and stover yields (2583 and 5126 kg/ha, respectively), which were statistically comparable to the pearl millet + green gram intercropping system in a 4:1 row ratio, yielding 2469 kg/ha grain and 4730 kg/ha stover.

12.1.2 Effect on quality parameters

Arpita *et al.* (2021) conducted a field experiment during the pre-*kharif* season of 2015 at the Agricultural Farm, Palli Siksha Bhavana, Visva-Bharti, Shriniketan, Birbhum, West Bengal, on red lateritic soil. The results showed that the highest oil content in sesame was recorded under the sesame + black gram intercropping system with a 4:4 row ratio, followed by sesame + green gram at the same row proportion, while the lowest oil content was observed in sole sesame grown in four rows. Protein content was maximum in sole sesame planted at 30 cm row spacing, followed by sesame + black gram in a 2:2 row ratio.

Panda *et al.* (2022) conducted a field experiment during the summer season of 2020–21 at the Experimental Farm of Centurion University of Technology and Management, Paralakhemundi, Odisha, located in a tropical region. The study revealed that sesame intercropped with groundnut in a 2:3 row ratio recorded the

highest oil content compared to all other treatments.

Shiyal *et al.* (2024) carried out a field experiment during the summer seasons of 2021 and 2022 at the College Farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, to assess the influence of pearl millet–pulse intercropping systems and nutrient management on the growth and yield of pearl millet (*Pennisetum glaucum* L.). The results indicated that the pearl millet + green gram intercropping system in a 2:1 row ratio recorded significantly higher protein content (11.57%) and protein yield (291.6 kg/ha), which was statistically at par with the pearl millet + cowpea intercropping system at the same row ratio, recording 11.19% protein content and 256.3 kg/ha protein yield.

12.1.3 Effect on nutrient content and uptake

Patra *et al.* (2011) evaluated the effect of organic nutrient sources on yield and nutrient uptake of groundnut (*Arachis hypogaea* L.) during the pre-*kharif* seasons of 2008–09 in the terai region of West Bengal**.** They reported that combined application of vermicompost 2.5 t/ha + phosphocompost 2.5 t/ha + Pressmud cake 2.5 t/ha + neem cake 2.5 t/ha brought significant improvement in NPK uptake by groundnut.

Kumawat *et al.* (2013) reported that intercropping system had significant effect total uptake of N, P, K, S and Zn, when compared to sole pigeon pea. Significantly higher values of total uptake (N, P, K, S and Zn) were recorded under sole pigeon pea. The lowest negative value of actual gain of S and Zn was recorded under paired intercropping. Rande *et al.* (2010) recorded maximum NPK uptake of 165.9 kg N, 18.3 kg P and 157.7 kg K/ha respectively by wheat with the application of 125% recommended N through vermicompost.

12.1.4 Effect on soil properties

Bhuva *et al.* (2017) conducted a field experiment during the *kharif* seasons from 2010–11 to 2012–13 at Nana Kandhasar, Surendranagar, Gujarat, to evaluate the performance of Groundnut-based intercropping systems under rainfed conditions**.** The study revealed that sole groundnut recorded the highest nutrient use productivity (27.88 kg/ha)**.** Among the intercropping treatments, groundnut + green gram (1:1) resulted in the maximum available nitrogen (220.2 kg/ha) and potassium (310.4 kg/ha) in the soil, while sole moth bean recorded the highest available phosphorus (29.2 kg/ha)**.**

12.1.5 Effect on economics

Yadav *et al.* (2013) conducted a field study during the *kharif* seasons of 2009 and 2010 at Kanpur, Uttar Pradesh, under rainfed conditions to evaluate the productivity and economic performance of sesame-based intercropping systems. The results showed that intercropping green gram + sesame in a 1:1 row ratio resulted in higher net returns, benefit–cost ratio and economic efficiency compared to other cropping systems.

Mandal and Pramanick (2014) conducted a field experiment during the pre-summer seasons of 2010 and 2011 at Mohanpur, West Bengal, to examine the competitive interactions between sesame and green gram under different intercropping row arrangements. The study revealed that the sesame + green gram intercropping system with a 2:2 row ratio generated the highest monetary advantage among the treatments.

Yadav *et al.* (2015) at Sardarkrushinagar, Gujarat, reported that net income was significantly higher under various intercropping systems compared to sole pearl millet. Overall economic analysis indicated that pulse crops grown alone and pearl millet intercropped with pulses or oilseeds produced higher net returns per hectare and benefit–cost ratio. Among the treatments, sole green gram and pearl millet intercropped with green gram in a 1:2 row ratio proved to be the most economically advantageous.

Bhuva *et al.* (2017) conducted a field experiment during the *kharif* seasons from 2010–11 to 2012–13 at Nana Kandhasar, Surendranagar, Gujarat, under rainfed conditions to evaluate yield performance, economic returns and post-harvest soil nutrient status in groundnut-based intercropping systems. The study revealed that the groundnut + sesame intercropping system in a 1:1 row ratio produced significantly higher net returns and benefit cost ratio compared to other planting patterns.

Khan *et al.* (2017) conducted on-farm experiments during 2015 and 2016 at farmers' fields under the On-Farm Research Division of the Bangladesh Agricultural Research Institute (BARI), Mymensingh, to identify an economically viable groundnut + sesame intercropping system. The results indicated that intercropping two or three rows of groundnut between paired rows of sesame resulted in higher gross return, gross margin and benefit–cost ratio compared to other intercropping arrangements.

Ram (2020) conducted a field experiment during the *kharif* season of 2017 at the Agricultural Research Station, Mandor, Jodhpur, on sandy loam soil under arid dryland conditions to evaluate the productivity and profitability of sesame-based intercropping systems. The study revealed that sesame intercropped with green gram in a 3:1 row ratio recorded the highest gross income, net returns and benefit–cost ratio compared to other treatments.

Suri *et al.* (2020) conducted a field investigation during the *kharif* season of 2015 at the Advanced Centre for Rainfed Agriculture, Rakh Dhiansar, SKUAST-Jammu, to evaluate the economic performance of different intercropping systems. The results indicated that the black gram + sesame intercropping system in a 5:1 row ratio recorded the highest net returns and benefit–cost ratio among the treatments.

Yadav *et al.* (2023) conducted a field experiment at MJRPU, Jaipur, during the summer seasons of 2021 and 2022 on sandy loam soils to evaluate the yield and economic performance of pearl millet (*Pennisetum glaucum* L.) intercropped with green gram (*Vigna radiata* L.). The results showed that the intercropping system of transplanted pearl millet with green gram in a 2:2 row ratio at 30 cm spacing recorded the highest net return (₹74,828/ha) and benefit–cost ratio (1:3.30) among all treatment.

Kumar *et al.* (2024) conducted a field experiment during the *kharif* season of 2020 in Haryana under dryland conditions to evaluate pearl millet + legume intercropping systems. The study revealed that the pearl millet + green gram intercropping system in an 8:4 row ratio at 30 cm spacing recorded higher net returns (₹41,256/ha) and benefit cost ratio (2.61) compared to other intercropping treatments.

Sowmiya *et al.* (2024) conducted a field experiment during the *rabi* season of 2023–24 at Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, to evaluate pearl millet–based intercropping systems under rainfed conditions. The results indicated that the pearl millet + green gram intercropping system in a 4:1 row ratio recorded the highest net returns (₹80,960/ha) and benefit–cost ratio (2.44), followed closely by the pearl millet + green gram system in a 6:1 row ratio, which achieved net returns of ₹63,987/ ha and a B:C ratio of 2.14.

12.1.6 Effect on yield assessment

Bhuva *et al.* (2017) conducted a field experiment during the *kharif* seasons from 2010–11 to 2012–13 at Nana Kandhasar, Surendranagar, Gujarat**,** to evaluate

groundnut-based intercropping systems under rainfed conditions**.** The results revealed that intercropping groundnut with sesame in a 1:1 row ratio recorded a significantly higher land equivalent ratio (1.18) compared to other planting patterns.

Chavan *et al.* (2019) conducted a field experiment titled "Production potential and economic feasibility of groundnut + sesame intercropping in different row proportions" at the Research Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the summer season of 2016–17**.** The study reported that the highest land equivalent ratio (LER) of 1.64 was obtained when groundnut was planted at 30 cm row spacing with one row of sesame intercropped in between**.**

12.2 Effect of different production system

12.2.1 Effect on growth, yield attributes and yield

Jat and Ahlawat (2010) observed significant increase in yield and yield attributes of pigeon pea and groundnut, system productivity (1.7 t/ha) in pigeon pea + groundnut intercropping system with application of FYM @ 5 t/ha.

Sharma *et al.* (2010) conducted experiment to study the effect of different crop residues in Pigeon pea based intercropping system. The results revealed that under application of different crop residues (pigoen pea stalks, sorghum stubbles and sunflower stalks) along with 50% and 100% RDF recorded almost identical yield of pigeon pea, pearl millet and green gram over their individual application and control.

Kumawat *et al.* (2013) reported that among the integrated nutrient management, application of 100% RDF + 50% of RDN through vermicompost + 5 kg Zn/ha gave significantly higher growth and yield attributes, grain yield.

Pal *et al.* (2016) observed that application of 100% RDF + 2.5 t/ha vermicompost the fertility level recorded its superiority by recording higher growth attribute and yield attribute with grain yield (1,831.8 kg/ha) and stalk yield (8,221.6 kg/ha) over all fertility levels.

Korat *et al.* (2023) conducted a field study at the Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Gujarat**,** during the 2019–20 agricultural year to assess the performance of different farming modules. The results revealed that conventional farming (CF) produced the highest seed (1233 kg/ha) and stalk yield (1898 kg/ha) of sesame, followed by organic farming (OF), while low-cost natural farming (LCNF**)** recorded the lowest yields. During the *kharif* season**,** farming

systems significantly influenced pod and haulm yield of groundnut, with CF recording the maximum pod (1759 kg/ha) and haulm yield (2415 kg/ha), which was statistically comparable with organic farming, whereas LCNF resulted in the minimum pod (1298 kg/ha) and haulm yield (1821 kg/ha).

Sujatha *et al.* (2023) conducted a field study at the Agricultural Research Station, Yellamanchili, Visakhapatnam district, Andhra Pradesh, during *rabi* 2016–17, *kharif* 2017–18 and *rabi* 2017–18 to evaluate the effect of farming systems on growth and yield of sesame. The results indicated that inorganic farming recorded superior growth and yield attributes, including higher plant height (112 cm), number of branches per plant (4.8), capsules per plant (97.4) and test weight (3.0 g), compared to organic farming. Consequently, seed yield under inorganic farming was higher across all three seasons, recording 530, 324 and 586 kg/ha, respectively.

Malakannavar *et al.* (2024) conducted field experiments at the Zonal Agriculture Research Station (ZARS), V.C. Farm, Mandya, Karnataka, India, during 2019 to 2022 to evaluate the effect of different farming practices on growth and yield of green gram and paddy. The pooled results indicated that the recommended package of practices (RPP) significantly enhanced growth and yield compared to other management systems. In green gram, recommended package of practice (RPP) recorded the tallest plants (34.85 cm), maximum number of branches (5.68/plant), and leaves (20.69/plant), resulting in a higher seed yield (536 kg/ha). In paddy, growth parameters including plant height (102.80 cm), number of tillers (15.86/hill), and leaves per hill (67.62/hill), as well as yield attributes such as panicle length (20.00 cm), panicle weight (2.57 g), and test weight (20.23 g), were significantly superior under RPP compared to other practices absolute control (AC) organic production system (OPS), Natural farming system.

12.2.2 Effect on quality parameters

Patra *et al.* (2011) conducted a field experiment at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar (West Bengal) during the pre-*kharif* seasons of 2008 and 2009 to evaluate the influence of organic nutrient sources on quality parameters of groundnut. The study revealed that application of phosphocompost at 5 t/ha resulted in the highest oil content (46.7 %), highest oil content (46.7 %), crude protein (22.4 %), soluble protein (10.5 %), total sugar (13.1 %), starch (14.8 %), calcium (143.92 mg/100g) and phosphorus (836.6 mg/100g).

Sujatha *et al.* (2023) conducted a field experiment at the Agricultural Research Station, Yellamanchili, Visakhapatnam district, Andhra Pradesh**,** during *rabi* 2016–17, *kharif* 2017–18 and *rabi* 2017–18 to assess the effect of farming systems on quality parameters of sesame**.** The study revealed that organically grown sesame recorded a higher oil (47.1%) and protein content (23.3%) compared to inorganic farming. than under the inorganic system across all three seasons.

12.2.3 Effect on nutrient content and uptake

Jat and Ahlawat (2010) reported that application of FYM @ 5t/ha significatly improved nutrient uptake (NPK) in Pigeon pea and Groundnut and recorded available S in soil after harvest (15.72 kg/ha) in Pigeon pea + Groundnut intercropping system.

Dholariya *et al.* (2021) conducted a field experiment at the Krishi Vigyan Kendra, Rajendrapur Farm, Navsari Agricultural University, Waghai**,** during the *kharif* seasons of 2018 and 2019 to evaluate the effect of organic nutrient management on soil properties, yield, and quality of finger millet (*Eleusine coracana* (L.) Gaertn.) under rainfed conditions of south Gujarat. The results indicated that application of 100 % recommended dose of nitrogen through biocompost significantly enhanced N, P, K and Ca content in both grain and straw. Among the liquid organic formulations tested, enriched banana pseudostem sap applied at 1 % recorded the highest uptake of N, P, K, and Ca by grain, straw, and total biomass.

Malakannavar *et al.* (2024) conducted field experiments at the Zonal Agriculture Research Station (ZARS), V.C. Farm, Mandya, Karnataka, India**,** during 2019 to 2022 to evaluate the effect of different farming practices on growth and yield of green gram and paddy**.** The pooled results indicated that the recommended package of practices (RPP) Among the production systems in green gram and paddy recorded higher uptake of nitrogen, phosphorus and potassium respectively as compared to organic farming system (OFS) and natural farming system (NFS).

12.2.4 Effect on soil properties

Hgarge *et al.* (2002) showed that application of vermicompost @ 5 t/ha + organic booster @ 1 lit/m^2 enhanced the availability of NPK and organic carbon in soil, also concluded that recommended doses of NPK and organic sources each alone could not perform significantly. The combined effect of organic + inorganic sources proved to be better over either organic alone or inorganic source alone.

Reddy *et al.* (2002) recorded significant increase in available N (221.2 kg/ha), P (21.2 kg/ha) and K (429.8 kg/ha) of soil with incorporation of crop residue like wheat straw (5 t/ha) with deep ploughing up to 20 cm.

Shwetha *et al.* (2011) studied the influence of different organic sources viz., vermicompost, FYM, and vermicompost + RDF and effect of different application rates of vermicompost on soil bacterial and fungal populations and reported significant increase in bacterial and fungal populations in soil applied with vermicompost + RDF and vermicompost at 15 t/ha over other treatments.

Nagar *et al.* (2016) revealed that higher available N, P and K were observed in pigeon pea + black gram and pigeon pea + green gram intercropping over sole pigeon pea system. Among combined use of organic manure, FYM + phosphocompost and pigeon pea stalk + phosphocompost resulted in improvement of chemical property of soil over recommended dose of fertilizer (RDF) application.

Korat and Mathukia (2022) evaluated the effect of low-cost natural, organic and conventional farming systems on soil properties at Junagadh Agricultural University during *rabi* 2019–20 to *kharif* 2020**.** The study indicated that organic and conventional farming significantly improved soil physical and biological properties, including microbial populations and soil organic carbon, compared to natural farming. Conventional farming**,** with the application of RDF along with FYM, also resulted in higher available N, P and K in the soil.

Korat *et al.* (2023) conducted a field study at Junagadh Agricultural University, Gujarat, during 2019–20 to evaluate the effect of low-cost natural, organic and conventional farming systems on soil properties. Conventional farming recorded the highest available nitrogen, phosphorus and potassium due to the application of recommended chemical fertilizers. In contrast, organic farming significantly improved soil organic carbon, sulphur and DTPA-extractable micronutrients (Fe, Zn, Cu and Mn)**.** Conventional farming ranked next, while natural farming recorded the lowest values for soil chemical parameters. The results showed that after harvest of groundnut and sesame during the summer season.

Sujatha *et al.* (2023) conducted a field experiment at the Agricultural Research Station, Yellamanchili, Visakhapatnam district, Andhra Pradesh, India**,** during *rabi* 2016–17, *kharif* 2017–18 and *rabi* 2017–18**.** They reported that organic cultivation of sesame led to an increase in soil organic carbon (0.34%) and higher availability of

nitrogen, phosphorus, potassium, and micronutrients compared to the inorganic production system.

12.2.5 Effect on Economics

Korat *et al.* (2023) conducted a field experiment at the Instructional Farm**,** Junagadh Agricultural University, Gujarat, during the 2019–20 agricultural year to evaluate the economics of different farming modules. During the summer season**,** conventional farming (CF) recorded the highest gross returns (₹1,60,028/ha) and net returns (₹1,14,684/ha) from sole groundnut and sesame cultivation. The organic farming module comprising biofertilizers, vermicompost, FYM, Panchagavya and biopesticides ranked second. In contrast**,** low-cost natural farming (LCNF) resulted in the lowest gross (₹1,11,306/ha) and net returns (₹70,042/ha)**.**

Ram *et al.* (2024) conducted a field experiment during summer 2022, *kharif* 2022 and *rabi* 2022–23 at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, to evaluate the economic performance of different farming systems. During the summer season, the results indicated that conventional farming (CF) recorded the highest gross returns (₹ 1,11,823/ha) and net returns (₹ 69,684/ha). This was followed by organic farming (OF)**,** whereas natural farming (LBNF) resulted in the lowest gross (₹ 88,112/ha) and net returns (₹ 49,406/ha)**.** The findings suggest that conventional farming was economically superior to organic and natural farming systems during the summer season under the agro-climatic conditions of Junagadh.

Sujatha *et al.* (2023) conducted a field experiment at the Agricultural Research Station, Yellamanchili, Visakhapatnam district, Andhra Pradesh, India, during *rabi* 2016–17, *kharif* 2017–18 and *rabi* 2017–18 to assess the economic performance of sesame under different farming systems. The study reported that the cost of cultivation was Rs. 12,807/ha under organic farming and Rs.16,413/ha**,** Net returns and benefit–cost (B:C) ratio were higher under the inorganic production system compared to the organic system.

13 Materials and methods:

13.1 Location **:** Instructional Farm, Department of Agronomy, College of Agriculture, JAU,

Junagadh-362001

13.2	**Year and season of experiment**	**:**	Summer 2026 and 2027
13.3	**Experimental design**	**:**	RBD (Factorial)

Experimental details:

1.	**Title of the Experiment**	**:**	Comparative performance of groundnut and sesame intercropping under different production system
2.	**No. of treatments**	**:**	9
3.	**No. of replications**	**:**	3
4.	**Spacing**	**:**	Groundnut : 30 x 10 cm Sesame : 30 x 10 cm
5.	**Crop and variety**	**:**	Groundnut : GJG 37 Sesame : GT 8
6.	**Seed rate**	**:**	Groundnut : 120 kg/ha Sesame : 3 kg/ha
7.	**Plot size: Gross**	**:**	5.0 m × 4.5 m
8.	**Plot size: Net**	**:**	4.0 m × 2.7 m
9.	**Recommended dose of fertilizer**	**:**	Groundnut 25:50:50 N: P_2O_5: K_2O kg/ha Sesame 50:25:40:20 N :P_2O_5:K_2O:S kg/ha

13.4 Treatment details

FACTOR (A)

A) Intercropping system

I_1: Sole Groundnut

I_2: Sole Sesame

I_3: Groundnut + Sesame (2:1)

FACTOR (B):

(B) Production system

P_1: Inorganic production system

P_2: Organic production system

P_3: Natural production system

Note:

1. **Inorganic production system**
   - Sole cropping of sesame (GT 8) and groundnut (GJG37)
   - Intercropping of groundnut and sesame in 2:1 ratio
   - Seed treated with recommended fungicide before sowing of seed
   - Application of recommended dose of chemical fertilizer RDF for Groundnut 25:50:50 N: P_2O_5: K_2O kg/ha and Sesame 50: 25: 40 : 20 N : P_2O_5 : K_2O : S kg/ha
   - Plant protection by recommended fungicides, insecticides and herbicides, if required.
2. **Organic production system**
   - Sole cropping of sesame (GT 8) and groundnut (GJG 37)
   - Intercropping of groundnut and sesame in 2:1 ratio
   - Soil application of FYM 5 t/ha with enrich tricoderma (2 kg/ha) at sowing
   - Plant protection by pheromone trap, Trichoderma, Beauveria, Metarhizium, NPV, etc., if required.
3. **Natural production system**
   - Sole cropping of sesame (GT 8) and groundnut (GJG 37)
   - Intercropping of groundnut and sesame in 2:1 ratio
   - Seed treatment with Beejamrut @ 300 ml/kg seed by spraying on groundnut and sesame seed, mix it well and dry before sowing
   - Soil application of GhanJeevamrut @ 2000 kg/ha at sowing
   - Soil application of Jeevamrut 1250 lit/ha with irrigation at sowing, 30, 60 & 90 DAS and 3 % Panchagvya at 45 and 60 DAS
   - Achhadan: Wheat straw mulch
   - Plant protection by Agniastra, Brahmastra, Neemastra, etc., if required

13.5 No. of replications : 3

13.6 Observations to be recorded:

13.6.1 Groundnut

13.6.1.1 Growth, yield attributes and yield

1. Plant population at initial and at harvest
2. Plant height at 30 DAS and at harvest
3. Number of nodules per plant at 45 DAS
4. Fresh weight of nodules per plant (mg)
5. Number of pods/plant
6. Number of kernals per pod
7. Pod yield (kg/ha)
8. Halum yield (kg/ha)

13.6.2 Sesame

13.6.2.1 Growth, yield attributes and yield

1. Plant population at initial and at harvest
2. Plant height at 30 DAS and at harvest
3. Number of branches per plant at harvest
4. Number of capsules/plant
5. Number of seeds per capsule
6. 1000 seed weight (g)
7. Seed yield (kg/ha)
8. Stalk yield (kg/ha)

13.6.3 Quality parameter

1. Protein content
2. Oil content

13.6.4 Land equivalent ratio

13.6.5 Nutrient content and uptake

1. Nutrients (NPK) content and uptake by crops (Groundnut and Sesame)

13.6.6 Soil study

1. Soil nutrient status (NPK) initial and after harvest
2. Microbial count initial and after harvest

13.6.7 Economic Studies

1. Gross returns (Rs/ha)

2. Net returns (Rs/ha)
3. Benefit cost ratio (B:C ratio)

14. Statistical analysis

The data will be statistically analysed using the analysis of variance technique as described by Gomez and Gomez (1984)**.** The critical difference (CD) will be calculated for comparison among the treatment means wherever the F-values are found significant at the 5 % of probability**.** Summary tables incorporating S.Em.±, C.D. and C.V. will be prepared to elucidate the magnitude and significance of various treatment effects.

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